JOURNAL OF HORTICULTURE AND POSTHARVEST RESEARCH
2024, VOL. 7(4), 361-388

Journal of Horticulture and Postharvest Research

Journal homepage: www.jhpr.birjand.ac.ir

University of Birjand

Evaluation the phenotypic diversity of some grapevine cultivars and genotypes based on morphological, phenological, biochemical and fruit characteristics (Case study: Khuzestan province, Iran)

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ARTICLE INFO

Original Article

Article history:
Received 19 April 2024
Revised 26 July 2024
Accepted 27 August 2024

Keywords:
Cluster analysis
Correlation
Grape
Morphological diversity
Resveratrol

DOI: 10.22077/jhpr.2024.7550.1377
P-ISSN: 2588-4883
E-ISSN: 2588-6169

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ABSTRACT

Purpose: This study aimed to gain knowledge about the genetic reserves of native Iranian grapevine (*Vitis vinifera* L.) cultivars and genotypes in tropical regions and to identify the best grapevine cultivars and genotypes existing in vineyards of Khuzestan province. **Research Method:** This study evaluated the phenotypic diversity of 60 grapevine cultivars and genotypes existing in tropical, subtropical region of Khuzestan province in Iran. **Findings:** The result showed that the most descriptive statistics in the most important quantitative traits are related to fresh weight of bunch, bunch length, bunch width, the number of berries per bunch, berry length, berry width, protein content, total soluble solids and titratanbe acidity. The native Iranian grape cultivars and genotypes of Khuzestan province included 'Bangi', 'Soltani' and 'Yershi' as the earliest, Iranian cultivars including 'Yaghouti Ghermez', 'Yaghouti Sabz' and 'Asgari' as mid-ripening and foreign cultivars including 'Flame Seedless' and 'Perlette' as late ripening respectively. The results of factor analysis showed that the highest coefficients of eigenvectors in 7 main components are related to the most important traits including fresh weight of bunch, fresh weight of berries, berry diameter, berry length, the number of berries per bunch, protein content, total soluble solids, titratable acidity and the content of chlorophyll which accounted for 84.28% of the total variance variation. To group cultivars and genotypes based on investigated traits from cluster analysis by Ward's method was used. Cultivars and genotypes were grouped in 9 main clusters in 5 Euclidean distances. **Research limitations:** No limitations were encountered. **Originality/Value:** In this research, the significant diversity of grapevine cultivars and genotypes existing in vineyards of Khuzestan province showed the superiority of native cultivars and genotypes such as 'Soltani', 'Bangi (Ghermez)' and 'Yershi' in some traits compared to other foreign cultivars.

INTRODUCTION

Grapevine (*Vitis vinifera* L.) has been known for a long time and has been used in various ways throughout the centuries. *Vinifera* cultivars have the best product quality and are cultivated and consumed in most temperate regions (Salimov et al., 2017). Grapes, as a prominent horticultural product, can be cultivated in different parts of the world and are among the most profitable fruit products worldwide. They are mainly consumed fresh or used to produce raisins and processed products (Kupe et al., 2021).

There are numerous theories about the evolution of the European grapevine (*Vitis vinifera* L.) (Jahnke et al., 2021). According to De-Candolle (1985), grapevines originated outside the Caucasus and Middle East regions of Asia. According to this classification, the European grapevine belongs to the Central Asian center of diversity, along with pistachios and almonds. The genus *Vitis* is believed to have more than 100 species. This genus is distributed in 10 regions of the world, all located in the northern hemisphere, including five regions in North America, where 29 species have been described; four regions in Asia, with at least 11 species; and only *Vitis vinifera* in a wide range including the Mediterranean and sub-Mediterranean and Caucasian floristic regions, extending to the Pontic, Caspian and Central Asian regions (Sargolzaei et al., 2021).

Grapevines are rare fruits, cultivated from tropical to temperate regions due to their great diversity. The common grapevine is widely distributed in temperate and subtropical regions of the world. It is estimated that 10,000 known grapevine cultivars are distributed in the world's wine-growing regions, and about 13 cultivars dominate global production, covering more than one-third of the world's vineyard area (FAO, 2020; Lacombe et al., 2013; Imazio et al., 2013).

Breeding programs to produce new cultivars for predicted future environmental conditions may be one of the most promising solutions to stabilize production, although this strategy is part of long-term solutions. Choosing the right cultivar reduces the inputs required for crop management and increases the sustainability of production (Santos et al., 2020).

Due to the interest of grape growers in developing new vineyards, it is critical for them to accurately identify and ensure the accuracy of the grapevine cultivar. Mistakes in grapevine cultivar identification can result in significant financial costs, not only for the growers, but also for the grape industry (Mena et al., 2014). For many years, the traditional identification of grapevine cultivars has been done by visual inspection of grapevines, known as amplography. The results of using amplography to identify grapevine cultivars are not accurate, and there may be changes in the definition of the descriptor due to environmental conditions and genetic variations (Razi et al., 2021). For example, the same grapevine cultivar in different environments shows variation in the size, shape, and color of berries and bunch. Amplography descriptions vary slightly depending on the health status of the grapevine cultivars and the interpretation of the observer (Antolin et al., 2020).

To determine grapevine traits, several multivariate statistical analyses such as principal components analysis and cluster analysis are used for quantitative and qualitative analysis. These techniques describe the morphological characteristics of horticultural crops (Zahedi et al., 2023). The berry shape index is used to differentiate grapevine cultivars, but fruit shape is a three-dimensional trait and should be defined using pleiotropic explanatory variables instead of a simple single index (Maeda et al., 2018).

Local grapevine cultivars are mainly grown in old vineyards located in old settlements and vineyards. These cultivars differ in terms of morphological traits and berry and grape size. They also differ in terms of phenology, harvest time, productivity and quality indicators. Local grapevine cultivars are essential for maintaining crop diversity and can also be important for the nutritional and economic security of many people. For smallholder farmers and farming communities in rural and marginal areas, the diversity of local grapevines can be a guarantee against low yields and provide specific raw materials for the preparation of traditional local foods. In each country where grapevines are grown, many local species contribute to the global diversity of grapevines (Antolin et al., 2020).

Diverse grapevine cultivars are important sources of locally adapted genes for breeding new grapevine cultivars. Significant clonal diversity can be observed in a grapevine cultivar. Therefore, the definition and identification of cultivars are of considerable scientific and practical importance in modern viticulture and amplography (Sargolzaei et al., 2021).

The important point is the lack of studies to identify local grapevine cultivars and genotypes in tropical and subtropical regions of Iran, especially in vineyards of Khuzestan province, the center of agriculture and horticulture. Khuzestan has an area of 64055 km^2 and a population of 4.7 million. It is located in the southwestern region of Iran and has a hot, arid and semi-arid climate; and with a suitable climate for growing grapevines, has a cultivated area of about 2164 ha (both fertile and non-fertile) with an average yield per unit area of 12662 $kg.ha^{-1}$ and a total production of 17245 tons (FAO, 2020).

This study aimed to gain knowledge about the genetic reserves of native Iranian cultivars and genotypes in tropical regions and to identify the best grapevine cultivars and genotypes existing in vineyards of Khuzestan province. Considering the different and unique climatic conditions of Khuzestan province, by studying the phenological and morphological traits and evaluating the diversity of cultivars and genotypes, it is possible to identify the important traits affecting grapevine yield and use them in breeding programs to identify important traits affecting the differentiation of cultivars and genotypes.

MATERIALS AND METHODS

The environmental and climatic characteristics of region

The Khuzestan province with an area of nearly 64000 km^2 in the southwestern region of Iran has an altitude lower than the level of the open seas to about 3400 m above the level of the open seas and between the longitude of 47º and 41′ to 50º and 39′ and the latitude of 29º and 58′ to 33º and 4′ (Fig. 1). The Khuzestan province has three regions in terms of elevation and altitude: mountains, foothills, and plains, of which about 25% is mountainous, about 20% is foothills and about 60% is plains (Ministry of Agricultural Jahad of Iran, 2021; Agricultural Jahad Organization of Khuzestan Province, 2021).

The Khuzestan province has different weather conditions from hot and dry to semi-arid, which during the years 1990 to 2020 (with 30-year average) has an average annual rainfall of 284.3 mm, an average annual relative humidity of 3.3 42%, the average minimum and maximum daily temperature ranges from 13.9°C to 33.9°C and the average minimum and maximum annual temperature ranges from -4.8°C to 53.7°C (Meteorological Organization of Khuzestan province, 2021).

Fig. 1. Location of Khuzestan Province in the southwest of Iran (Safieddin-Ardebili & Khademalrasoul, 2022).

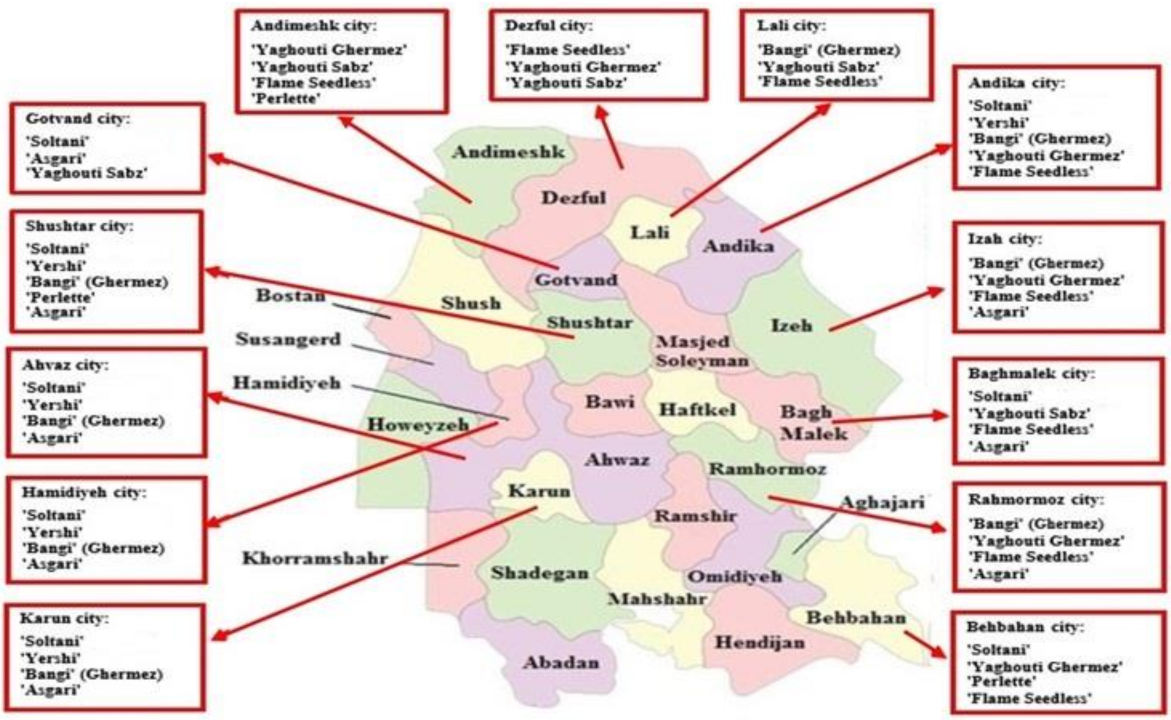

Fig. 2. Geographical location of cultivars or genotypes sampled in vineyards by each selected city in Khuzestan province of Iran (13 selected regions).

Plant Materials

In order to evaluate the phenotypic diversity based on the morphological and phenological characteristics of some cultivars and genotypes of grapevine (*Vitis vinifera* L.) existing in the vineyards of Khuzestan province, firstly based on the geographical location including the type of region based on the plain, foothills and mountains and also the climatic and ecological conditions of the place, including the height above sea level, temperature, humidity, rainfall and other indicators, the location of the vineyards were identified based on the priorities mentioned above. After determining the location of the vineyards and by identifying the existing cultivars and genotypes, the types of cultivars and genotypes were determined based on whether they are native or foreign, and they were identified for testing and sampling. The phenotypic diversity of 60 grape varieties, including cultivars, genotypes and clones of native, local and foreign varieties, including ‘Soltani’, ‘Bangi’ (Ghermez), ‘Yershi’, ‘Sabz Dorosht’, ‘Mocheh’, ‘Roghani’, ‘Nameless’ ‘Asgari’, ‘Yaghouti Ghermez’, ‘Yaghouti Sabz’, ‘Flame Seedless’ and ‘Perlette’ and etc. In the vineyards of Khuzestan province, which were evaluated based on 105 morphological, phenological, fruit and biochemical traits in 3 years from 2019 to 2022 (Table 1 and Fig. 2).

Table 1. The names of grape cultivars and genotypes of vineyards in Khuzestan province to study phenotypic diversity.

No.	Cultivar/Genotype	Origin	Place of sampling		No.	Cultivar/Genotype	Origin	Place of sampling	
			Region name	Altitude above sea level (m)				Region name	Altitude above sea level (m)
1	‘Soltani’	Iran	Ahvaz	16	31	‘Yaghouti Sabz’	Iran	Andimeshk	146
2	‘Soltani’	Iran	Karun	12	32	‘Yaghouti Sabz’	Iran	Dezful	143
3	‘Soltani’	Iran	Hamidiyeh	15	33	‘Yaghouti Sabz’	Iran	Lali	493
4	‘Soltani’	Iran	Shushtar	65	34	‘Yaghouti Sabz’	Iran	Gotvand	599
5	‘Soltani’	Iran	Andika	339	35	‘Yaghouti Sabz’	Iran	Baghmalek	917
6	‘Soltani’	Iran	Baghmalek	917	36	‘Yaghouti Sabz’	Iran	Ramhormoz	179
7	‘Bangi’ (Ghermez)	Iran	Ahvaz	16	37	‘Flame Seedless’	USA	Andimeshk	146
8	‘Bangi’ (Ghermez)	Iran	Karun	12	38	‘Flame Seedless’	USA	Dezful	143
9	‘Bangi’ (Ghermez)	Iran	Hamidiyeh	15	39	‘Flame Seedless’	USA	Baghmalek	917
10	‘Bangi’ (Ghermez)	Iran	Shushtar	65	40	‘Flame Seedless’	USA	Behbahan	325
11	‘Bangi’ (Ghermez)	Iran	Andika	339	41	‘Flame Seedless’	USA	Izeh	835
12	‘Bangi’ (Ghermez)	Iran	Ramhormoz	179	42	‘Flame Seedless’	USA	Andika	339
13	‘Yershi’	Iran	Ahvaz	16	43	‘Perlette’	USA	Andimeshk	146
14	‘Yershi’	Iran	Karun	12	44	‘Perlette’	USA	Dezful	143
15	‘Yershi’	Iran	Hamidiyeh	15	45	‘Perlette’	USA	Shushtar	65
16	‘Yershi’	Iran	Shushtar	65	46	‘Perlette’	USA	Ramhormoz	179
17	‘Yershi’	Iran	Andika	339	47	‘Perlette’	USA	Behbahan	325
18	‘Yershi’	Iran	Behbahan	325	48	‘Perlette’	USA	Lali	493
19	‘Asgari’	Iran	Ahvaz	16	49	‘Roghani’	Iran	Ahvaz	16
20	‘Asgari’	Iran	Karun	12	50	‘Roghani’	Iran	Karun	12
21	‘Asgari’	Iran	Hamidiyeh	15	51	‘Roghani’	Iran	Hamidiyeh	15
22	‘Asgari’	Iran	Shushtar	65	52	‘Mocheh’	Iran	Ahvaz	16
23	‘Asgari’	Iran	Ramhormoz	179	53	‘Mocheh’	Iran	Karun	12
24	‘Asgari’	Iran	Gotvand	599	54	‘Mocheh’	Iran	Hamidiyeh	15
25	‘Yaghouti Ghermez’	Iran	Izeh	835	55	‘Nameless’	Iran	Ahvaz	16
26	‘Yaghouti Ghermez’	Iran	Andika	339	56	‘Nameless’	Iran	Karun	12
27	‘Yaghouti Ghermez’	Iran	Andimeshk	146	57	‘Nameless’	Iran	Hamidiyeh	15
28	‘Yaghouti Ghermez’	Iran	Lali	493	58	‘Sabz Dorosht’	Iran	Dezful	143
29	‘Yaghouti Ghermez’	Iran	Behbahan	325	59	‘Sabz Dorosht’	Iran	Dezful	143
30	‘Yaghouti Ghermez’	Iran	Dezful	143	60	‘Sabz Dorosht’	Iran	Dezful	143

Measurement of traits

To determine the phenological traits, coding was performed based on OIV (2020), IPGRI (2008) and UPOV (2008) grapevine descriptors (Table 2). Quantitative and qualitative differentiating and diversifying traits were identified in the cultivar and genotype study, and the traits were evaluated and compared among cultivars and genotypes.

Some of the important qualitative traits are berry color, the depth of the cut of leaf blade, the number of leaf lobes, leaf width folding, color of upper and lower leaf surface, and shape of young shoot terminal. The quantitative traits are divided into two categories; the first category includes some traits that can be measured in the vineyard, such as growth size of shoot, the length and width of leaf, plant height, the number of bunches per plant, the number of bunch shoulders per bunch, the number of berries per bunch shoulders (Rasouli et al., 2013; Khadivi-Khub et al., 2014). The second category includes some traits such as leaf area, specific leaf area (Koundouras et al., 2008), fresh and dry weight of bunch, fresh and dry weight of shoot, fresh and dry weight of leaf, titratanbe acidity (Amerine & Ough, 1980) and sugar content (Khochert, 1987) that can be measured in the laboratory. The quantitative measuring of total soluble solids was done using a MASTER-3M manual analog optical refractometer, ATAGO CO, made in Japan (Khochert, 1987). The protein content was determined according to the method of Bradford (1976). Using bovine serum albumin as the standard. To measure the amount of cis and trans-resveratrol according to the method of Cvejic et al. (2010), Sykam HPLC device made in Germany equipped with Sykam S3210 UV/V is detector was used. Based on the inhibition time and using a spectrophotometer, the amount of cis and Trans resveratrol in the sample of different parts of the plant was measured at the wavelength of 280 and 306 nm and expressed as micromoles pergram of fresh weight.

Table 2. Some evaluated characteristics and their measurement in the investigated grape samples based on the grape descriptor of OIV (2020), IPGRI (2008) and UPOV (2008).

No.	Traits	Unit	Measurement method
1	Flowering time	score	1= too early, 2= very early, 3= early, 4= early to medium, 5= medium, 6= medium late, 7= late, 8= very late, 9= too late
2	Leafing time	score	1= early, 3= medium, 5= late
3	Bush growth	score	3= weak, 5= moderate, 7= strong
4	Shape of the tip of young shoot	score	1= closed, 3= slightly open, 5= half open, 7= wide open, 9= fully open
5	Strength of shoot	score	1= 0-60 cm, 3= 60-90 cm, 5= more than 90 cm
6	Leaf width	score	1= less than 100 square centimeters, 3= 100 to 125 square centimeters, 5= 125 to 150 square centimeters, 7= 150 to 175 square centimeters, 9= more than 175 square centimeters
7	The number of leaf lobes	score	1= no lobes, 2= three lobes, 3= five lobes, 4= seven lobes, 5= six of seven lobes
8	Color of the upper surface of leaf	score	1= very light green, 3= light green, 5= medium green, 7= dark green, 9= very dark green
9	The cutting depth of the leaf	score	1= less than 4 mm, 3= 4 to 8 mm, 5= 8 to 12 mm, 7= 12 to 16 mm, 9= more than 16 mm
10	Bunch size	score	3= small, 5= medium, 7= large, 9= very large
11	Bunch density per plant	score	3= open, 5= medium, 7= tight, 9= very tight
12	Bunch shoulder density per bunch	score	3= open, 5= medium, 7= compact
13	Ripening time of fruit	score	41= very early, 3= early, 5= medium, 7= late, 9= very late
14	Berry density per bunch	score	3= low, 5= medium, 7= high
15	Peduncle separation	score	1= difficult, 2= fairly easy, 3= very easy
16	Anthocyanin color of pedicel	score	0= no color, 1= very weak, 3= weak, 5= medium, 7= strong, 9= very strong

Table 2 (*Continued*). Some evaluated characteristics and their measurement in the investigated grape samples based on the grape descriptor of OIV (2020), IPGRI and UPOV (2008).

No.	Traits	Unit	Measurement method
17	Anthocyanin color of berry mesocarp	score	1= none or very little, 3= little, 5= moderate, 7= high, 9= very high
18	Thickness of berry skin	score	3= thin, 5= medium, 7= thick
19	Juiciness of berry	score	1= little water, 2= slightly watery, 3= very watery
20	Berry color	score	1= green-yellow, 2= light red, 3= dark red, 4= gray, 5= purple, 6= navy blue
21	Berry firmness	score	1= soft, 2= slightly hard, 3= hard
22	Berry shape	score	1= rectangular, 2= oval, 3= broad oval, 4= round, 5= flat, 6= ovoid, 7= open ovoid, 8= ovoid, 9= conical
23	Berry size	score	1= very small, 3= small, 5= medium, 7= large, 9= very large
24	Seed presence	score	1= none, 2= incomplete growth, 3= complete growth
25	Growth size of Shoot	cm	Digital Caliper
26	Tendril length	cm	Digital Caliper
27	Length of internode	mm	Digital Caliper
28	Fresh weight of shoot	g	Digital Scale
29	Dry weight of shoot	g	Digital Scale
30	Fresh weight of leaf	g	Digital Scale
31	Dry weight of leaf	g	Digital Scale
32	Leaf Area	cm^2	Digital Caliper
33	The cutting depth of leaf	mm	Digital Caliper
34	The ratio of leaf dry weight to leaf area	$mg.cm^{-2}$	Calculate ratio
35	Specific leaf area (SLA)	$cm^2.mg^{-1}$	Calculate Leaf Area/Occupied Area Ratio
36	The rachis length	mm	Digital Caliper
37	Bunch length	mm	Digital Caliper
38	Bunch width	mm	Digital Caliper
39	The ratio of length to width of the bunch	ratio	Digital Caliper
40	The peduncle length	mm	Digital Caliper
41	The length of bunch shoulder	mm	Digital Caliper
42	The width of bunch shoulder	mm	Digital Caliper
43	The ratio of length to width of bunch shoulder	ratio	Calculate ratio
44	The ratio of rachis length of bunch to rachis length of bunch shoulder	ratio	Calculate ratio
45	Berry length	mm	Digital Caliper
46	Berry width	mm	Digital Caliper
47	The ratio of length to width of berry	ratio	Calculate ratio
48	Berry Diameter	mm	Digital Caliper
49	The number of berries per bunch	number	Count
50	The number of berries per bunch shoulder	number	Count
51	The number of bunch shoulder per bunch	number	Count
52	Fresh weight of the bunch	g	Digital Scale
53	Fresh weight of bunch shoulder	g	Digital Scale
54	Fresh weight of berries	g	Digital Scale
55	Fresh weight of berries per bunch	g	Digital Scale
56	Fresh weight of berries per bunch shoulder	g	Digital Scale
57	Total pedicels of fresh weight of berries per bunch	g	Digital Scale
58	Dry weight of bunch	g	Digital Scale
59	Dry weight of bunch shoulder	g	Digital Scale
60	Dry weight of berry	mg	Digital Scale
61	Dry weight of berries per bunch	g	Digital Scale
62	Dry weight of bunch shoulders per bunch	g	Digital Scale

Table 2 (*Continued*). Some evaluated characteristics and their measurement in the investigated grape samples based on the grape descriptor of OIV (2020), IPGRI and UPOV (2008).

No.	Traits	Unit	Measurement method
63	Fresh weight of rachis	mg	Digital Scale
64	Fresh weight of peduncle	mg	Digital Scale
65	The pedicel of fresh weight of berries	mg	Digital Scale
66	Fresh weight of rachis of the total bunches	g	Digital Scale
67	The ratio of fresh weight of rachis of bunch shoulder to fresh weight of rachis bunch	ratio	Calculate ratio
68	Dry weight of rachis	g	Digital Caliper
69	Dry weight of peduncle	g	Digital Scale
70	Dry weight pedicel of berry	mg	Digital Scale
71	The total pedicels of dry weight of berries per bunch	g	Digital Scale
72	The ratio of dry weight of rachis of bunch shoulder to dry weight of rachis bunch	g	Digital Scale
73	The peduncle length of the bunch	ratio	Calculate ratio
74	The pedicel length of bunch	mm	Digital Caliper
75	Fresh weight of peduncle	mm	Digital Caliper
76	The pedicel length of berry	mm	Digital Caliper
77	Seed weight	mg	Digital Scale
78	Seed diameter	mm	Digital Caliper
79	Seed length	mm	Digital Caliper
80	Titratanbe acidity	mEq	[1*] A= S.N.F.E/C× 100
81	Total soluble solids (TSS)	$mg.g^{-1}$ F.W.	Khochert (1987)
82	Protein content	$mg.g^{-1}$ F.W.	Bradford method (1976)
83	Content of trans-resveratrol in tendril	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
84	Content of trans-resveratrol in petiole	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
85	Content of trans-resveratrol in leaf	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
86	Content of trans-resveratrol in pedicel	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
87	Content of trans-resveratrol in the skin of unripe berries	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
88	Content of trans-resveratrol in mesocarp of unripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
89	Content of trans-resveratrol in skin of unripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
90	Content of trans-resveratrol in mesocarp of ripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
91	Content of trans-resveratrol in seeds of unripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
92	Content of trans-resveratrol in seeds of ripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
93	Content of cis-resveratrol in the tendril	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
94	Content of cis-resveratrol in petiole	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
95	Content of the cis-resveratrol content in leaf	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
96	Content of cis-resveratrol in pedicel	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
97	Content of cis-resveratrol in the skin of unripe berries	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
98	Content of cis-resveratrol in mesocarp of unripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
99	Content of cis-resveratrol in the skin of unripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
100	Content of cis-resveratrol in the mesocarp of ripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
101	Content of cis-resveratrol in seeds of unripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
102	Content of cis-resveratrol in seeds of ripe berry	$mg.L^{-1}$	[2*] $E_{1cm}^{1\%}=(A\times100/M\times100)\times(100/100\text{-}H)$
103	Total chlorophyll content	$mg.g^{-1}$ F.W.	Lichtenthaler & Buschmann method (2001)
104	The content of chlorophyll a	$mg.g^{-1}$ F.W.	Lichtenthaler & Buschmann method (2001)
105	The content of chlorophyll b	$mg.g^{-1}$ F.W.	Lichtenthaler & Buschmann method (2001)

[1*] A= The amount of fruit acid (gr/100ml), S= the amount of NaOH consumed, N = NaOH normalization, F = invoice naoh, C = The amount of fruit extract, E = Ekiwalan acid included.
[2*] A= absorption rate, H = moisture content, M = sample mass in grams. measured by Spectrophotometer.

Statistical analysis

Frequency of traits, descriptive statistics, the simple correlation between the traits and cluster analysis were performed in SPSS (Version 21.0). The correlation between traits was calculated using Pearson's correlation analysis. Through the factor rotation technique and the maximum variance method (Varimax Method), the separation of factors was carried out, and factor coefficients of 0.5 and above were considered significant in each main and independent factor. Cluster analysis and grouping of cultivars and genotypes were performed using Ward's or the minimum variance method, based on the square of the Euclidean distance and calculating the distances after standardizing the data (Rasouli et al., 2013; Zahedi et al., 2023).

RESULTS

Descriptive statistics of traits

In examining quantitative and qualitative traits measured in the studied cultivars and genotypes of grapevines in vineyards of Khuzestan province, the parameters of minimum, maximum, mean, standard deviation and coefficient of variation (CV%) are presented in Table 3. The results showed that in evaluated quantitative traits such as growth size of shoot (73.80-104.71 cm), the length of internode (68.65-99.56 mm), leaf area (53.13-153.76 cm^2) and specific leaf area (135.45-344.28 $cm^2.g^{-1}$), the rachis length (112.17-313.28 mm), the bunch length (95.98-279.68 mm), the bunch width (61.69-157.03 mm), the peduncle length (37.59-146.09 mm), the length of bunch shoulder (28.84-113.52 mm), the width of bunch shoulder (22.82-64.06 mm), berry length (11.03-30.89 mm), the number of berries per bunch (73.90-688.83 berries), fresh weight of bunch (165.172-1062.57 g), fresh weight of bunch shoulder (15.08-91.74 g), dry weight of bunch (17.76-217.73 g), dry weight of berry (44.36-397.38 mg) had the largest range of difference between minimum and maximum.

The measurement of the diversity of the most important vegetative characteristics between grape cultivars and genotypes in the vineyards of Khuzestan province showed that the native cultivar or genotype 'Soltani'in the vineyards of Khuzestan province in terms of shoot growth size with 100.5 cm and specific leaf area with 339.45 $cm^2.g^{-1}$ and the native cultivar or genotype had the highest value, and the leaf area with 151.94 cm in the native cultivar or genotype 'Sabz Dorosht' had the highest amount.

In the vineyards of Khuzestan province, the highest bunch length with 311.78 mm, bunch width with 154.65 mm, the length of bunch shoulder with 105.77 mm, the width of bunch shoulder with 58.86 mm, the number of berries per bunch with 633.55 berries, fresh weight of bunch with 958.77 g, it is related to the native cultivar or genotype of 'Soltani'.

The highest fresh weight of bunch shoulder with 88.33 g was in the native cultivar or genotype 'Sabz Dorosht' in the vineyards of Khuzestan province. The native cultivar or genotype 'Yershi' in the vineyards of Khuzestan province had the largest berry length with 9.89 mm. 'Yaghouti Ghermez' cultivar had the highest dry weight of bunch with 212.73 g and dry weight of berries with 390.45 mg.

The native cultivar or genotype 'Mocheh' had the highest shoot growth with 65.40 cm, the 'Flame Seedless' cultivar with 45.30 cm^2 had the highest leaf area and the 'Perlette' cultivar with 339.45 $cm^2.mg^{-1}$ had the highest specific leaf area. The smallest bunch length with 102.66 mm, bunch width with 50.5 mm, length of bunch shoulder with 31.47 mm, width of bunch shoulder with 17.94 mm, berry length with 8.88 mm, the number of berries per bunch with 65.10 berries, fresh weight with of bunch 197.44 cm, fresh weight of bunch shoulder 11.20 g, dry weight of bunch with 12.69 g and the dry weight of berry with 374.39 mg was related to the native cultivar or genotype 'Mocheh' in the Khuzestan province conditions.

The highest percentage of variation coefficient (CV%) in examining qualitative morphological and phenological traits such as flowering time (21.29%), leafing time (58.05%), leaf width (71.88%), bunch size (39.96%), bunch density per plant (28.36%), berry density per bunch (29.41%), berry size (31.87%), the presence of seeds (50.42%), berry shape (39.13%), juiciness of berry (44.09%), berry color (49.67%) and anthocyanin color of the berry mesocarp (85.04%) which has a high phenotypic diversity among the cultivars and genotypes of grapes available in the vineyards of Khuzestan province.

Also, the bunch length (22.46%), bunch width (28.18%), berry length (26.75%), berry width (27.15%), the number of berries per bunch (78.44%), fresh weight of bunch (50.51%), fresh weight of bunch shoulder (46.74%), dry weight of bunch (60.07%), fresh weight of berry (50.52%), protein content (37.20%) had the highest percentage of coefficient of variation (CV.) in genetic diversity.

The highest coefficient of variation (CV.) in content of trans-resveratrol in different plant organs including tendril (60.38%), petiole (55.97%), ripe berry skin (60.13%) and also the content of cis-resveratrol in different plant organs including tendril (63.21%), petiole (39.69%), leaf (52.65 %), pedicel (65.19%) unripe berry skin (60.80%) had the highest percentage of coefficient of variation.

According to Table 1, out of the 60 clones of the studied, only the native 'Yershi' cultivar and genotype in the vineyards of Khuzestan province (including 6 clones) had complete seeds and 54 clones had no seeds, and the reason for the high coefficient of variation of trans and cis-resveratrol content in unripe and ripe berry seeds is that only the 'Yershi' cultivar or genotype had developed seeds. While in the studied clone, other native cultivars or genotypes and foreign cultivars did not have seeds.

Frequency distribution of traits

The frequency percentages of some of the most important qualitative traits examined in the cultivars and genotypes studied in parts A to J is presented in Figure 3. Various traits related to morphological characteristics, including flowering time, leafing time, leaf width width, the cutting depth of leaf, bunch size, berry shape, berry color, berry size, berry density per bunch, and late or early fruit showed a relatively high diversity among the studied cultivars and genotypes.

Native grape cultivars and genotypes in Khuzestan province such as 'Soltani', 'Bangi' (Ghermez), 'Yershi', 'Roghani' and 'Mocheh', due to suitable climatic and ecological conditions in terms of sufficient water, light, temperature, humidity, etc., have higher growth rate and efficiency. They have earlier flowering (March) compared to other Iranian grape cultivars 'Yaghouti Ghermez', 'Yaghouti Sabz' and 'Asgari' (March-April) and foreign grape cultivars 'Flame Seedless' and 'Perlette' (April) available in vineyards of Khuzestan province. Other studied Iranian grape cultivars, such as 'Yaghouti Ghermez', 'Yaghouti Sabz' and 'Asgari' had earlier flowering compared to foreign cultivars such as 'Flame Seedless' and 'Perlette' (Fig. 3a).

Table 3. Descriptive statistics of quantitative traits (phenological, morphological and pomological traits) in grape cultivars and genotypes studied in Khuzestan province.

No.	Traits	Unit	Range	Min.	Max.	Average	Std.	CV.%
1	Flowering time	score	2	3	5	3.70	0.79	21.29
2	Leafing time	score	4	1	5	2.60	1.51	58.05
3	Bush shape	score	3	1	4	2.25	1.10	48.84
4	Shape of the tip of the young shoot	score	4	5	9	6.20	1.34	21.58
5	Strength of the shoot	score	2	5	7	6.3	0.96	15.27
6	Leaf width	score	6	1	7	2.73	1.96	71.88
7	The number of leaf lobes	score	2	5	7	5.10	0.44	8.62
8	Color of the upper surface of the leaf	score	2	3	5	4.30	0.96	22.37
9	The cutting depth of the leaf width	score	6	1	7	4.70	1.72	36.60
10	Bunch size	score	6	3	9	5.50	2.20	39.96
11	Bunch density per plant	score	4	5	9	6.40	1.82	28.36
12	Bunch shoulder density per bunch	score	4	3	7	5.60	1.29	23.06
13	Fruit ripening time	score	4	3	7	4.80	1.41	29.41
14	Berry density per bunch	score	4	3	7	4.80	1.41	29.41
15	Peduncle separation	score	4	3	7	4.40	1.58	35.80
16	Anthocyanin color of pedicel	score	6	3	9	4.90	1.62	33.12
17	Anthocyanin color of berry mesocarp	score	6	1	7	3.00	2.55	85.04
18	Thickness of berry skin	score	4	3	7	5.40	1.51	27.95
19	Juiciness of berry	score	2	1	3	1.90	0.84	44.09
20	Berry color	score	2	1	3	1.30	0.65	49.67
21	Berry firmness	score	1	2	3	2.40	0.49	20.58
22	Berry shape	score	4	2	6	3.90	1.85	39.13
23	Berry size	score	6	3	9	5.80	0.61	31.87
24	Seed presence	score	2	1	3	1.20	0.51	50.42

Also, more benefit and better efficiency from the climatic and ecological conditions in Khuzestan province due to the native Iranian grape cultivars and genotypes, including Soltani', 'Bangi' (Ghermez), 'Yershi', 'Roghani' and 'Mocheh' in earlier leafing (February) compared to other Iranian grape cultivars including 'Yaghouti Ghermez', 'Yaghouti Sabz' and 'Asgari' (February-March) and foreign cultivars 'Flame Seedless' and 'Perlette' (March-April) are available in the vineyards of Khuzestan province (Fig. 3b).

The climatic and ecological conditions in Khuzestan province, in terms of the presence of sufficient water, light, temperature, humidity, etc., will cause favorable vegetative growth of the plant, especially in the leaves, which will cause a favorable and rapid increase in the leaf surface. In native Iranian grape cultivars and genotypes of grapes in vineyards of Khuzestan province, 'Soltani', 'Bangi' (Ghermez) and 'Yershi' had more leaf area than foreign cultivars ('Flame Seedless' and 'Perlette'), but compared to other Iranian grape cultivars ('Yaghouti Ghermez', 'Yaghouti Sabz' and 'Asgari') studied, the leaf area was slightly more and the difference didn't show much. The native Iranian grape cultivars and genotypes of 'Roghani' and 'Mocheh' grapes available in vineyards of Khuzestan province had the lowest amount of leaf area compared to other cultivars (Fig. 3c).

The results showed that the native Iranian grape cultivars or genotypes of Khuzestan province 'Soltani', 'Bangi' (Ghermez) and 'Yershi' had more and deeper incisions in the leaves compared to the other Iranian and foreign cultivars. The reason for these differences in the leaves of native plants is probably some kind of adaptation to the hot weather conditions of the region (Fig. 3d).

The native cultivars and genotypes of grapes in the vineyards of Khuzestan province, including 'Soltani' and 'Yershi' and Iranian grape cultivars 'Yaghouti Ghermez' and 'Yaghouti Sabz' were large and almost the same size in terms of grape size. The foreign cultivars 'Flame Seedless' and 'Perlette' had a smaller bunch size. The native Iranian grape cultivars and genotypes of 'Roghani' and 'Mocheh' had the smallest bunch size among the investigated grape cultivars and genotypes (Fig. 3e).

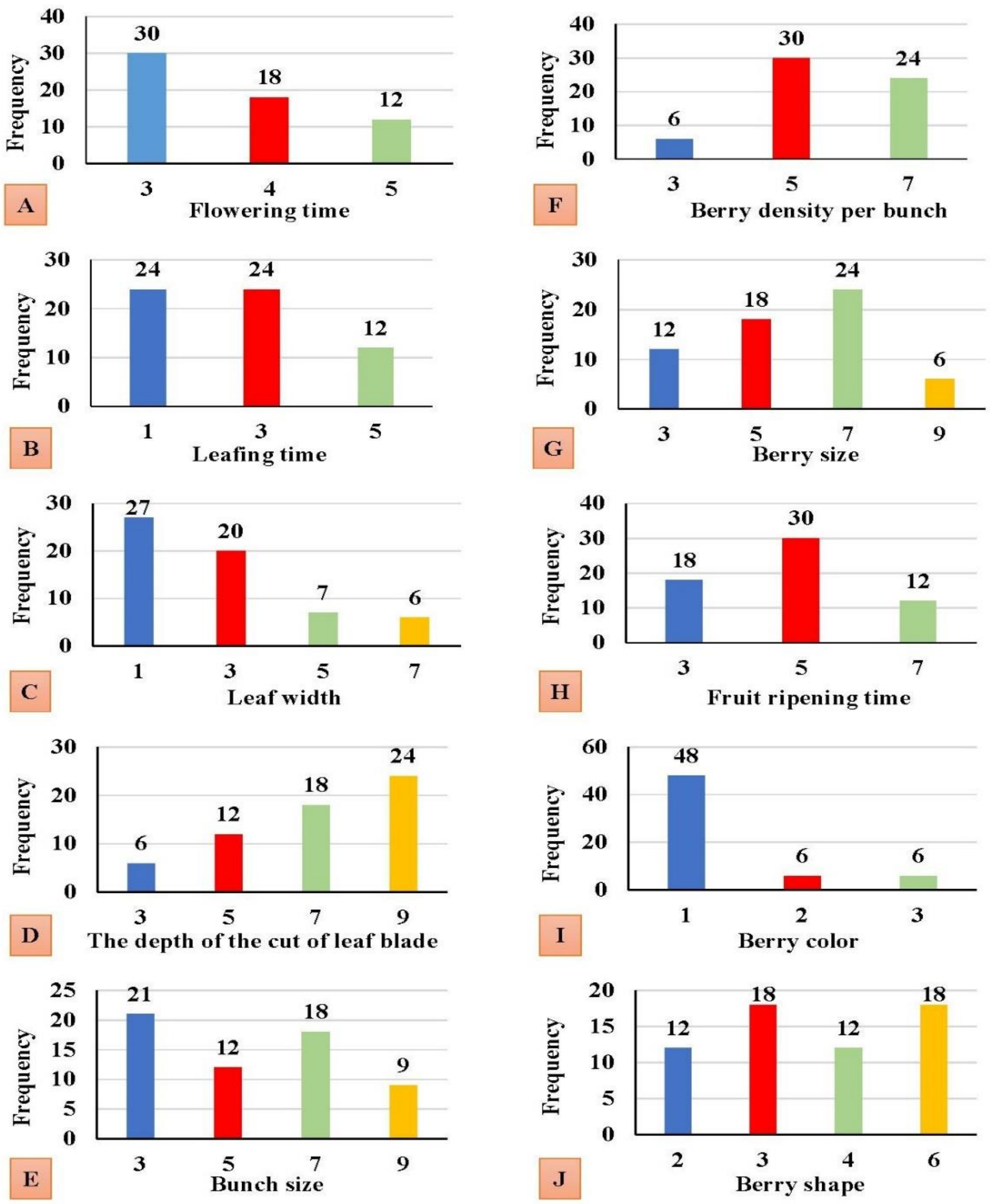

Fig. 3. The frequency of some important studied traits in different cultivars and genotypes of grapes existing in the vineyards of Khuzestan province as follows. **A)** The frequency of flowering time in the studied cultivars and genotypes of grapevines. 1=Too early, 2= Very early, 3= Early, 4= Early to moderate, 5= Moderate, 6= Moderate to late, 7= Late, 8= Very late, 9= Too late. **B)** Frequency of leafing time in the studied cultivars and genotypes of grapevines. 1=early, 3= intermediate, 5= late. **C)** The frequency of leaf width in the studied cultivars and genotypes of grapevines. 1= less than 100 cm^2, 3= 100 to 125 cm^2, 5= 125 to 150 cm^2, 7= 150 to 175 cm^2, 9= more than cm^2. **D)** The frequency of the depth of wide leaf incisions in the studied cultivars and genotypes of grapevines. 1= less than 4 mm, 3= 4 to 8 mm, 5= 8 to 12 mm, 7= 12 to 16 mm, 9= more than 16 mm. **E)** The frequency of bunch size in the studied cultivars and genotypes of grapevines. 3= small, 5= medium, 7= large, 9= very large. **F)** The frequency of berry density in the bunch in studied cultivars and genotypes of grapevine s. 3= open, 5= medium, 7= compact. **G)** The frequency of seed size in the studied cultivars and genotypes of grapevines. 1= very small, 3= small, 5= medium, 7= large, 9= very large. **H)** The frequency of fruit ripening time in the studied cultivars and genotypes of grapevines. 1= very early, 3= early, 5= medium, 7= late, 9= very late. **I)** The frequency of berry color in the studied cultivars and genotypes of grapevines. 1= green-yellow, 2= light red, 3= dark red, 4= gray, 5= purple, 6= navy blue. **J)** The frequency of berry shape in the studied cultivars and genotypes of grapevines. 1= rectangular, 2= oval, 3= broad oval, 4= round, 5= flat, 6= ovoid, 7= open ovoid, 8= ovoid, 9= conical.

The native Iranian grape cultivars and genotypes in vineyards of Khuzestan province, including 'Soltani' and 'Yershi' and Iranian grape cultivars ('Yaghouti Ghermez' and 'Yaghouti Sabz'), had the highest berry density per bunch compared to foreign cultivars ('Flame Seedless' and 'Perlette'). Native and local Iranian grape cultivars and genotypes of 'Roghani' and 'Mocheh' had the lowest berry density per bunch among the studied grape cultivars and genotypes (Fig. 3f).

Also, native grape cultivars and genotypes of Khuzestan province such as 'Soltani' and 'Yershi' grapes had larger berry size than other Iranian grape cultivars ('Yaghouti Ghermez','Yaghouti Sabz' and 'Asgari') and non- Iranian grape cultivars ('Flame Seedless' and 'Perlette'). The smallest berry size was obtained by native Iranian grape cultivars and genotypes 'Roghani' and 'Mocheh' (Fig. 3g).

The native Iranian grape cultivars and genotypes including 'Soltani', 'Bangi' (Ghermez), 'Yershi', 'Roghani' and 'Mocheh' were earlier (May) than other cultivars. The grape cultivars 'Yaghouti Ghermez', 'Yaghouti Sabz', and 'Asgari' (May-June) were medium, and the foreign cultivars 'Flame Seedless' and 'Perlette' (June) were late (Fig. 3h).

By studying the cultivars and genotypes of grapes available in the vineyards of Khuzestan province, it was observed that the color of the berries in the native 'Soltani' cultivar or genotype is from bright yellow to greenish yellow, the native 'Bangi' (Ghermez) cultivar or genotype has a light red to medium red color, the native 'Yershi' cultivar or genotype has a yellow to green and bright red color, the native 'Sabz Dorosht' cultivar or genotype has a green color, the native 'Roghani' cultivar or genotype has a shiny green color, the native 'Mocheh' cultivar or genotype has a green color, 'Nameless' cultivar or genotype has a yellow to green color, the 'Yaghouti Sabz' cultivar has a green color, the 'Yaghouti Ghermez' cultivar has a light red to medium red color, the 'Asgari' cultivar has a yellow-green color, the 'Flame Seedless' cultivar has a light red to medium red color, and the 'Perlette' cultivar has a variable green color (Fig. 3i).

The berry shape varied from round to oval in Iranian grape cultivars and genotype and round to elongated oval in foreign cultivars (Fig. 3j).

Simple correlation of traits

There was a significant correlation between variables related to vegetative growth and fruit characteristics. The results showed that the growth size of shoot had a positive and significant relationship with the dry weight of shoot (r=0.99). The relationship between tendril length and dry weight of leaf (r=0.97) was positive and significant. Internode length had a significant positive relationship with dry weight of shoot (r=0.99). The length of bunch shoulder showed a positive and significant relationship with bunch length (r=0.87). Berry length had a positive and significant relationship with berry width (r=0.95), fresh weight of berry (r=0.84), dry weight of berry (r=0.71), dry weight of bunch shoulder (r=0.71). Also, the fresh weight of bunch shoulder had a significant and negative relationship with rachis length (r= -0.26). The length of bunch shoulder has a negative and significant correlation with dry weight of berry (r= -0.49). The specific leaf area has a negative and significant relationship with the characteristics of bunch length (r= -0.31) and bunch width (r= -0.49).

Principal Component Analysis

Component analysis prior to cluster analysis is useful to determine the relative importance of the role of variables. In general, component analysis is performed to determine the role of each trait in the diversity among the genotypes under study. The first component contains the most variance, followed by the second component, and the last component contains the least variance. The main purpose of this analysis is to obtain eigenvalues in the hope that the variances of many components are so small that they can be ignored. The best results from this analysis are obtained when the primary variables have a high correlation; otherwise, this analysis is useless. Under favorable conditions (high correlation), the principal components can serve as criteria to show different aspects of the data. It is also important to know that it is possible to reduce the number of primary variables in this analysis (Soltani, 2002).

The results showed that the 7 principal components accounted for 22.77, 17.27, 12.77, 11.39, 9.14, 5.99, and 4.95% of the variance changes, respectively, and a total of up to 84.28% of the total variance of the variables (Table 4). The relative variance of each factor indicates its importance, expressed as a percentage of the total variance of the characteristics studied. The results show the placement of some important traits in different factors, with their positive and negative factor coefficients.

In the first factor (PC_1), fruit vegetative and biochemical traits explained 22.77% of the variance as the most important traits for grouping genotypes in cluster analysis (Table 5).

Important vegetative characteristics in the first factor (PC_1) such as shoot growth size, length of internode, fresh weight of the shoot, dry weight of shoot, the ratio of the length to the width of the berry, and traits as content of trans-resveratrol in leaf, content of trans-resveratrol in the skin of unripe berries, total chlorophyll content, the content of chlorophyll a and the content of chlorophyll b the most important biochemical of fruit have the highest coefficients were eigenvectors (Table 5).

In the second factor (PC_2), the length of bunch shoulder, the number of berries per bunch, Dry weight of berry, trans-resveratrol content in tendril and petiole trans-resveratrol content were salient and important characteristics and had the highest coefficients. This group explained 17.27% of the variance (Table 5).

In the third factor (PC_3), seed weight, seed diameter and seed length had the highest eigenvector coefficients and explained 12.77% of the variance (Table 5).

In the fourth factor (PC_4), the peduncle length of the bunch, the pedicel length of the bunch and the pedicel length of the berry were the primary characteristics with the highest coefficients and explained 11.39% of the variance (Table 5).

In the fifth factor (PC_5), the total dry weight of peduncle had the highest coefficients and explained 9.14% of the variance (Table 5).

In the sixth factor (PC_6), the ratio of leaf dry weight to leaf area**,** specific leaf area and protein content had the highest coefficients and justified 5.99 % of the variance of the variables (Table 5).

In the seventh factor (PC_7), the ratio of the length to the width of the bunch has the highest coefficients with 4.95 % of the variance (Table 5).

Table 4. The amount of eigenvalues, percentage of variance and cumulative variance of the decomposition into factors in the first 7 factors.

Factor	Eigen values	Eigen values to Percent Variance	Cumulative percent variance
1	18.21	22.77	22.77
2	13.81	17.27	40.04
3	10.22	12.77	52.81
4	9.12	11.39	64.20
5	7.32	9.14	73.34
6	4.79	5.99	79.33
7	3.96	4.95	84.28

Table 5. Coefficients related to 1 to 7 principal components of grape cultivars and genotypes studied in Khuzestan province.

No.	Traits	Main Component						
		1	2	3	4	5	6	7
1	Growth size of shoot	0.846	-0.336	-0.044	-0.131	-0.265	-0.029	-0.175
2	Tendril length	0.538	0.225	0.215	0.367	0.454	-0.081	-0.067
3	Length of internode	0.846	-0.336	-0.044	-0.131	-0.265	-0.029	-0.175
4	Fresh weight of shoot	0.846	-0.336	-0.044	-0.131	-0.265	-0.029	-0.175
5	Dry weight of shoot	0.822	-0.343	-0.056	-0.147	-0.249	-0.035	-0.176
6	Fresh weight of leaf	0.537	0.223	0.214	0.366	0.457	-0.082	-0.068
7	Dry weight of leaf	0.532	0.138	0.129	0.245	0.577	-0.059	-0.106
8	Leaf Area	0.271	0.387	-0.167	0.434	0.465	0.397	-0.314
9	The cutting depth of the leaf	0.137	-0.299	0.269	-0.298	-0.104	-0.619	0.407
10	The ratio of leaf dry weight to leaf area	-0.062	0.396	-0.283	0.290	0.024	0.580	-0.361
11	Specific Leaf Area (SLA)	0.631	0.342	-0.089	0.141	0.335	-0.212	0.441
12	The rachis length	0.592	0.406	0.173	-0.196	0.127	-0.236	0.466
13	Bunch length	0.467	0.021	0.420	-0.487	0.164	-0.143	-0.088
14	Bunch width	0.042	0.350	-0.372	0.390	-0.022	-0.055	0.547
15	The ratio of length to width of the bunch	0.466	0.510	-0.296	0.541	-0.090	0.195	0.136
16	The peduncle length	0.374	0.662	-0.133	0.187	-0.361	0.315	0.097
17	The length of bunch shoulder	0.507	0.460	-0.420	0.349	0.013	0.143	0.009
18	The width of bunch shoulder	0.025	0.364	0.336	0.099	-0.494	0.242	0.250
19	The ratio of length to width of bunch shoulder	-0.127	-0.308	0.146	-0.483	0.520	-0.362	0.183
20	The ratio of rachis length of bunch to rachis length of bunch shoulder	0.421	-0.631	-0.487	-0.028	0.173	0.104	-0.017
21	Berry length	0.498	-0.613	-0.366	0.011	-0.009	0.036	-0.062
22	Berry width	-0.439	-0.066	-0.302	-0.048	0.447	0.162	0.037
23	The ratio of length to width of berry	0.760	-0.250	0.117	0.228	-0.039	0.333	0.222
24	Berry Diameter	0.212	0.865	0.227	-0.343	-0.106	-0.013	-0.048
25	The number of berries per bunch	0.529	0.449	0.280	0.076	0.043	-0.341	0.096
26	The number of berries per bunch shoulder	0.652	0.477	0.248	0.118	-0.052	-0.251	0.107
27	The number of bunch shoulder per bunch	0.507	0.602	0.159	-0.490	0.097	0.007	-0.006
28	Fresh weight of the bunch	0.746	-0.310	-0.089	0.245	0.093	-0.261	-0.024
29	Fresh weight of bunch shoulder	0.446	-0.621	-0.243	0.198	-0.061	-0.012	-0.202
30	Fresh weight of berries	0.510	0.655	0.212	-0.406	0.027	-0.012	-0.034
31	Fresh weight of berries per bunch	0.749	-0.231	0.000	0.349	0.013	-0.282	-0.025
32	Fresh weight of berries per bunch shoulder	0.026	0.227	0.147	-0.296	0.112	-0.098	0.467
33	Total pedicels of fresh weight of berries per bunch	0.549	0.225	-0.061	-0.543	0.141	0.185	0.026
34	Dry weight of bunch	0.536	-0.478	-0.395	-0.316	0.276	0.063	0.141
35	Dry weight of bunch shoulder	0.201	-0.837	-0.329	-0.053	0.060	0.004	-0.185
36	Dry weight of berry	0.585	-0.003	-0.121	-0.632	0.270	0.277	0.021
37	Dry weight of berries per bunch	0.697	-0.132	-0.072	-0.013	0.031	-0.243	0.179
38	Dry weight of bunch shoulders per bunch	0.439	0.244	-0.207	-0.288	0.187	0.379	0.037
39	Fresh weight of rachis per bunch	-0.406	0.189	-0.510	-0.412	0.223	0.362	0.298
40	Fresh weight of peduncle	-0.108	-0.305	-0.189	-0.341	0.345	-0.083	0.408
41	The pedicel of fresh weight of berries	0.323	0.738	-0.203	-0.182	0.001	0.077	0.352

Cluster Analysis

Cluster analysis is a method for grouping different populations. In this method, different cultivars or genotypes are measured based on P (variable) and items that are very similar to each other are placed in the same group. The advantage of this analysis is to find those elements that have the greatest genetic distance from each other for use in breeding programs. The other advantages of this method are finding the true groups and reducing the data (Soltani, 2002; Zahedi et al., 2023).

In this study, cluster analysis by Ward's method was used to group the genotypes based on the studied traits and at 5 Euclidean distances the cultivars and genotypes were grouped into 9 main clusters, (Fig. 4). The most obvious distinguishing characteristics of the groups included phenological traits such as leafing time, flowering time, early maturity and vegetative vigor, and morphological characteristics such as all traits related to bunches and berries such as bunch and berry size, berry shape, color and weight.

Table 5 (*Continued*). Coefficients related to 1-7 principal components of grape cultivars and genotypes studied in Khuzestan province.

No.	Traits	Main Component						
		1	2	3	4	5	6	7
42	Fresh weight of rachis of the total bunches	-0.518	0.245	-0.383	-0.333	0.026	0.068	0.428
43	The ratio of fresh weight of rachis of bunch shoulder to fresh weight of rachis bunch	0.368	-0.083	-0.400	-0.586	0.502	0.174	-0.014
44	Dry weight of rachis	0.170	-0.354	-0.465	-0.522	0.542	0.167	0.021
45	Dry weight of peduncle	0.411	-0.286	0.147	0.441	-0.476	0.002	0.040
46	Dry weight pedicel of berry	0.432	0.546	0.426	-0.026	-0.242	0.099	0.158
47	The total pedicels of dry weight of berries per bunch	0.615	0.086	-0.347	-0.277	0.550	0.016	0.178
48	The ratio of dry weight of rachis of bunch shoulder to dry weight of rachis bunch	-0.581	-0.526	-0.287	-0.082	0.315	-0.202	0.059
49	The peduncle length of the bunch	0.208	0.017	-0.457	0.734	0.410	-0.051	0.057
50	The pedicel length of bunch	0.282	0.118	-0.349	0.805	0.280	-0.085	0.101
51	The pedicel length of berry	-0.178	0.059	-0.331	0.773	0.373	-0.232	-0.051
52	Seed weight	0.140	-0.077	0.841	0.105	0.436	0.212	-0.011
53	Seed diameter	0.140	-0.077	0.841	0.105	0.436	0.212	-0.011
54	Seed length	0.139	-0.076	0.842	0.105	0.436	0.212	-0.011
55	Titratanbe acidity	-0.149	0.185	-0.104	0.158	0.282	-0.203	-0.148
56	Total soluble solids (TSS)	0.408	-0.144	0.364	0.341	-0.553	0.149	0.314
57	Protein content	0.069	-0.309	0.055	0.488	-0.194	0.504	0.425
58	Content of trans-resveratrol in tendril	0.353	0.847	-0.069	-0.122	-0.140	-0.120	-0.261
59	Content of trans-resveratrol in petiole	0.080	-0.809	0.367	-0.035	-0.036	-0.284	0.195
60	Content of trans-resveratrol in leaf	0.786	-0.077	-0.249	-0.278	-0.022	0.333	0.205
61	Content of trans-resveratrol in pedicel	-0.037	-0.719	0.365	0.167	-0.299	0.065	0.446
62	Content of trans-resveratrol in the skin of unripe berries	0.761	-0.107	-0.297	-0.205	-0.047	0.316	0.321
63	Content of trans-resveratrol in mesocarp of unripe berry	-0.171	0.031	-0.083	0.130	-0.307	0.794	0.270
64	Content of trans-resveratrol in skin of unripe berry	-0.045	-0.648	0.527	0.005	-0.265	-0.335	0.219
65	Content of trans-resveratrol in mesocarp of ripe berry	0.493	-0.479	-0.323	-0.370	0.414	0.098	0.045
66	Content of trans-resveratrol in seeds of unripe berry	0.141	-0.077	0.841	0.105	0.436	0.212	-0.011
67	Content of trans-resveratrol in seeds of ripe berry	0.141	-0.077	0.841	0.105	0.436	0.212	-0.011
68	Content of cis-resveratrol in the tendril	0.387	0.784	-0.199	0.197	0.028	-0.213	-0.232
69	Content of cis-resveratrol in petiole	0.301	0.516	-0.127	0.261	-0.033	-0.470	0.389
70	Content of the cis-resveratrol content in leaf	0.271	0.693	0.130	-0.457	-0.347	-0.050	-0.201
71	Content of cis-resveratrol in pedicel	0.275	0.792	-0.063	-0.187	-0.097	-0.414	-0.054
72	Content of cis-resveratrol in the skin of unripe berries	0.442	-0.423	0.221	0.196	-0.464	0.351	0.321
73	Content of cis-resveratrol in mesocarp of unripe berry	0.469	-0.159	-0.295	0.739	0.164	-0.091	0.120
74	Content of cis-resveratrol in the skin of unripe berry	0.331	-0.101	-0.348	0.747	0.356	-0.155	0.005
75	Content of cis-resveratrol in the mesocarp of ripe berry	0.685	-0.092	0.176	-0.039	-0.256	0.023	-0.423
76	Content of cis-resveratrol in seeds of unripe berry	0.138	-0.076	0.843	0.105	0.437	0.212	-0.011
77	Content of cis-resveratrol in seeds of ripe berry	0.138	-0.076	0.843	0.105	0.437	0.212	-0.011
78	Total chlorophyll content	0.846	-0.336	-0.044	-0.131	-0.265	-0.029	-0.175
79	The content of chlorophyll a	0.846	-0.336	-0.044	-0.131	-0.265	-0.029	-0.175
80	The content of chlorophyll b	0.846	-0.336	-0.044	-0.131	-0.265	-0.029	-0.175

Group 1: This group included 6 cultivars and genotypes out of 60 investigated grapes cultivars and genotypes such as the native Iranian grape cultivars and genotypes of 'Mocheh' (regions of Ahvaz, Hamidiyeh, Karun) and 'Roghani' (regions of Ahvaz, Hamidiyeh, Karun). The native Iranian grape cultivars and genotypes of Khuzestan province with similar geography and tropical climate were included in this group. The cultivars and genotypes of this group had relatively early setting, earlier ripening; small bunches with low density of berries per bunch, small berries, almost firm with berries of spherical shape and green color which is shiny in

'Roghani' genotype. In this group, cultivars and genotypes had lower sugar and higher titratable acidity and were completely seedless or had incomplete seeds, which is the result of stenospermocarpy. The average of some important characteristics in the native Iranian grape cultivar or genotype of 'Mocheh' is the leaf area with 77 cm^2, specific leaf area with 215 $cm^2.g^{-1}$, bunch length with 100 mm, berry length with 11 mm, number of berries per bunch with 78 berries, bunch weight with 220 g and berry weight with 1.3 g. Also, the average of some important characteristics in native Iranian grape cultivar or genotype of 'Roghani' are leaf area with 91 cm^2, specific leaf area with 214 $cm^2.g^{-1}$, bunch length with 126 mm, berry length with 15 mm, number of berries per bunch with 106 berries and berry weight with 2.15 g.

Group 2: This group included 6 cultivars and genotypes out of 60 investigated grapes cultivars and genotypes such as the foreign cultivar of 'Perlette' (regions of Lali, Ramhormoz, Behbahan, Gotvand, Izeh and Andimeshk) which has medium to late setting, mid-season ripening, medium to large bunches with medium density of berries in the bunch. This group had relatively elongated berry shape and medium firmness. The grapes were juicy, completely seedless or with incomplete seeds. Due to the fact that this variety was foreign and its geographical distance and peculiarities, it was placed in a separate group and the most distant group compared to the Sultani variety. In the foreign cultivar of 'Perlette', the average of some important characteristics are examples of leaf area with 109 cm^2, specific leaf area with 275 $cm^2.g^{-1}$, bunch length with 89 mm, berry length with 14 mm and berry weight with 2.1 g.

Group 3: This group included 6 cultivars and genotypes out of 60 investigated grapes cultivars and genotypes such as the Iranian grape cultivar 'Asgari' (regions of Ahvaz, Shushtar, Baghmalek, Izeh, Gotvand and Ramhormoz). This group had medium to late bearing cultivars, mid-season ripening, medium to large bunches, medium berry density in the bunch, relatively elongated berries and medium firmness. They were juicy, completely seedless or with incomplete seeds. The average of some important characteristics in the non-native Iranian grape cultivar 'Asgari' are leaf area with 55 cm^2, specific leaf area with 165 $cm^2.g^{-1}$, bunch length with 67 mm, berry length with 14 mm and berry weight with 2.35 g.

Group 4: This group included 6 cultivars and genotypes out of 60 investigated grapes cultivars and genotypes such as the foreign cultivar of 'Flame Seedless' (regions of Andimeshk, Dezful, Andika, Behbahan, Lali and Baghmalek) which, due to the climate of the region, had later flowering and ripening than other native and local cultivars of the region. They had medium sized vines with favorable growth and varying bunch sizes from small to large and with open to compact vine density. They also had yellow to medium red berries with oval to egg-shaped oval berries. In the foreign cultivar of 'Flame Seedless', the average of some important characteristics are leaf area with 143 cm^2, specific leaf area with 259 $cm^2.g^{-1}$, bunch length with 78 mm, berry length with 18 mm and berry weight with 2.2 g.

Group 5: This group included 12 cultivars and genotypes out of 60 investigated grapes cultivars and genotypes such as the Iranian grape cultivars 'Yaghouti Ghermez' (regions of Andika, Dezful, Shushtar, Izeh, Behbahan and Andimeshk) and 'Yaghouti Sabz' (regions of Gotvand, Ramhormoz, Andimeshk, Dezful, Baghmalek and Lali). Both cultivars had medium to high vegetative vigor, early to medium fruit ripening, medium flowering time, early to mid-season ripening and a relatively full crop with large and dense bunches, spherical and red to purple and green berry color. Both varieties were used for two purposes (fresh consumption and raisin production) and had a medium to high sugar content. The leaf area with 111 cm^2, specific leaf area with 205 $cm^2.g^{-1}$, bunch length with 60 mm, berry length with 13 mm and berry weight with 2.8 g as the most important characteristics of non-native Iranian grape cultivar is 'Yaghouti Ghermez'. Also, the average of some important characteristics in the native Iranian grape cultivar or genotype of 'Yaghouti Sabz' is the leaf area with 92 cm^2, specific leaf area with 178 $cm^2.g^{-1}$, bunch length with 84 mm, berry length with 12 mm and berry weight with 2 g.

Group 6: This group included 6 cultivars and genotypes out of 60 investigated grapes cultivars and genotypes such as the native grape cultivar and genotype of 'Yershi' (regions of Karun, Hamidiyeh, Ahvaz, Shushtar, Andika and Ramhormoz) as the native cultivar or genotype of Khuzestan which, according to the climate of the province, had earlier leafing, flowering and ripening than other non-native and local cultivars. They had medium sized bushes with favorable growth and large and compact bunches. They also have yellow to medium red berries that are oval to ovoid. The average of some important characteristics in the native and local Iranian grape cultivar or genotype of 'Yershi' are leaf area with 111 cm^2, specific leaf area with 205 $cm^2.g^{-1}$, bunch length with 60 mm, berry length with 13 mm and berry weight with 2.8 g.

Group 7: This group included 3 cultivars and genotypes out of 60 investigated grapes cultivars and genotypes such as the native Iranian grape cultivar or genotype of 'Sabz Dorosht' (regions of Dezful 1, Dezful 2 and Dezful 3). Its berries were large, seedless, green and had a larger bunch with higher density and weight compared to other cultivars. In native and local Iranian grape cultivar or genotype 'Sabz Dorosht', the average of some important characteristics are leaf area with 111 cm^2, specific leaf area with 235 $cm^2.g^{-1}$, bunch length with 63 mm, berry length with 24 mm and berry weight with 4.9 g.

Group 8: This group included 3 cultivars and genotypes out of 60 investigated grapes cultivars and genotypes such as the native Iranian grape cultivar or genotype of 'Soltani', (regions of Andika, Shushtar and Karun). leaf area with 93 cm^2, specific leaf area with 184 $cm^2.g^{-1}$, bunch length with 71 mm, berry length with 15 mm and berry weight with 3.3 g are the main characteristics of the native and local cultivar or genotype of Iranian 'Soltani' grapes in the eighth group.

Group 9: This group included 12 cultivars and genotypes out of 60 investigated grapes cultivars and genotypes such as the native Iranian grape cultivars and genotypes of Khuzestan province 'Bangi' (Ghermez), (regions of Andika, Lali, Hamidiyeh, Ramhormoz, Shushtar and Karun) and 'Soltani', (regions of Behbahan, Gotvand and Hamidiyeh) and 'Nameless', (regions of Ahvaz, Hamidiyeh and Karun). The average of some important characteristics in the native and local Iranian grape cultivar or genotype of 'Bangi' (Ghermez) are leaf area with 82 cm^2, specific leaf area with 219 $cm^2.g^{-1}$, bunch length with 65 mm, berry length with 20 mm and berry weight with 6.3 g. Also, the average of some important characteristics in the native Iranian grape cultivar or genotype of 'Soltani' are leaf area with 77 cm^2, specific leaf area with 194 $cm^2.g^{-1}$, bunch length with 63 mm, berry length with 16 mm and berry weight with 3.5 g. In the native Iranian grape cultivar or genotype of 'Nameless', the average of some important characteristics are leaf area with 66 cm^2, specific leaf area with 189 cm^2 g^{-1}, bunch length with 67 mm, berry length with 18 mm and berry weight with 4.58 g.

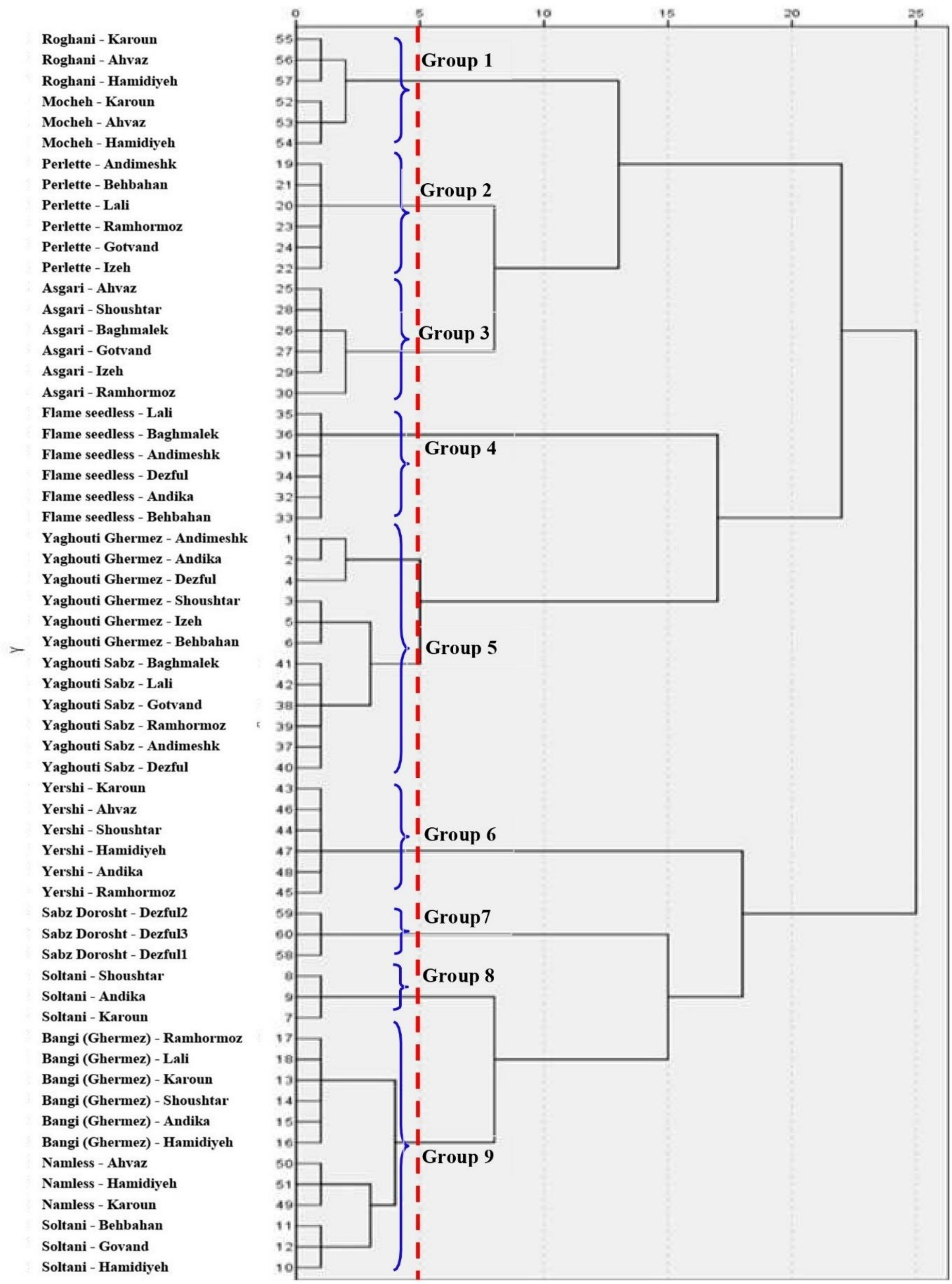

Fig. 4. Dendrogram showing relationship between 60 cultivars and genotypes of grapes, available in the vineyards of Khuzestan province located in the southwest of Iran, and at 5 Euclidean distances based on studied traits using cluster analysis by Ward's method.

The groups 8 and 9, included the native Iranian grape cultivar and genotype of Khuzestan province with similar geography and tropical climatic conditions. According to the climate of the region, these cultivars and genotypes have earlier leafing, flowering and ripening than the cultivars of other regions, and they have medium bushes with favorable growth and diverse bunch sizes from small to large and with open to compact density. They also have yellow to medium-red berry color and oval to egg-shaped oval berries and are fully seeded or have incomplete seeds. Cultivars and genotypes in these two groups were similar to each other in most of the traits compared to other cultivars and genotypes.

According to the separation of factors, determination of the effect of each trait on the diversity of phenological, morphological and pomological traits and identification of the most important traits affecting the diversity and difference of cultivars and genotypes in vineyards of Khuzestan province, it was concluded that the first factor belongs to vegetative traits of shoot, the second factor to berry traits, the third factor to seed traits, the fourth factor to rachis, peduncle, pedicel and the fifth factor to leaf traits. The most important traits include internode length, branch length, branch weight, number of berries per bunch, dry weight of berries, seed weight, seed diameter, seed length, content of trans-resveratrol in seeds of unripe grapevine, content of trans-resveratrol in seeds of ripe berry, content of cis-resveratrol in seeds of unripe berry, content of cis-resveratrol in seeds of ripe berry, pedicel length, leaf area, leaf specific area, leaf dry weight, and total soluble solids.

These results indicate that the cultivars and genotypes studied in terms of best quality traits had visible differences in growth and reproduction, and these superior traits create diversity. The variations observed are due to the different occurrence of the traits in the cultivars and genotypes (Fig. 5 and Fig. 6).

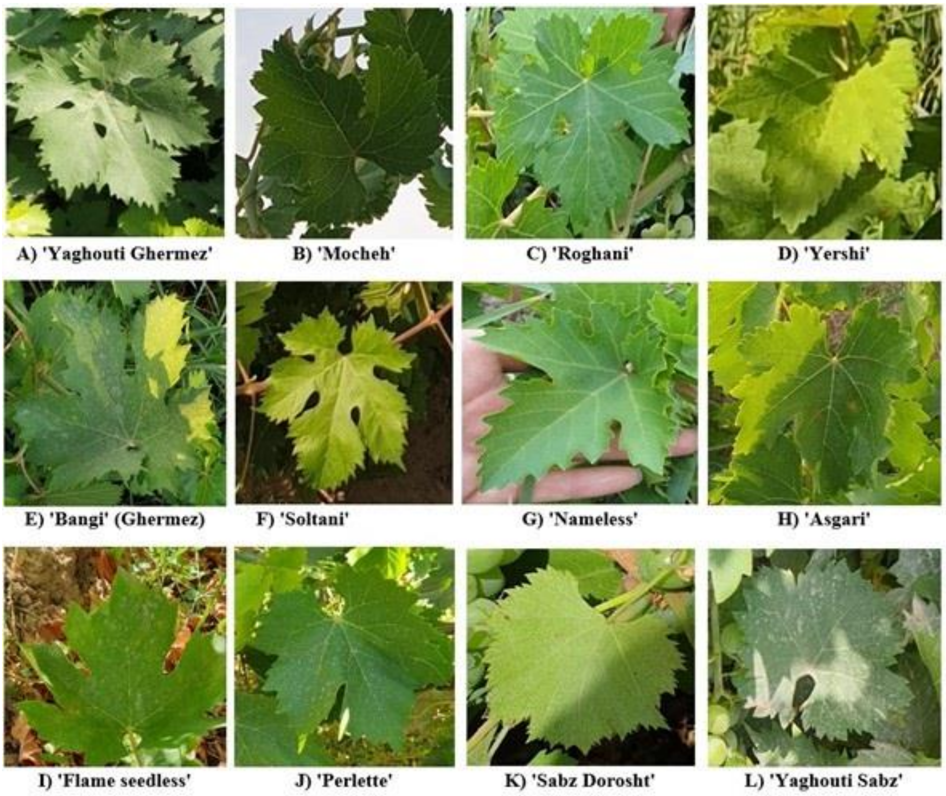

Fig. 5. Variations observed in leaf characteristics (included size, color, shape) of grape cultivars and genotypes grown in vineyards of Khuzestan province. A) 'Yaghouti Ghermez', B) 'Mocheh', C) 'Roghani', D) 'Yershi' , E) 'Bangi' (Ghermez), F) 'Soltani', G) 'Nameless', H) 'Asgari', I) 'Flame Seedless', J) 'Perlette', K) 'Sabz Dorosht' and L) 'Yaghouti Sabz'.

The difference in vine biomass, berry size, berry density and weight, presence or absence of seeds in the berry, seed size, leaf width size and leaf area, total soluble solids, and resveratrol content in different parts of the plant are among the most important traits that differ among cultivars; and the native and local Iranian grape genotypes such as 'Soltani', 'Bangi' (Ghermez), 'Yershi', 'Mocheh', 'Roghani', 'Sabz Dorosht' and grape cultivars such as 'Yaghouti Ghermez', 'Yaghouti Sabz', 'Asgari' and foreign cultivars such as 'Flame Seedless' and 'Perlette' in vineyards of Khuzestan province.

By identifying the most prominent characters to separate and group the cultivars and genotypes in the vineyards of Khuzestan province, it was determined that among the native Iranian grape cultivars and genotypes, 'Mocheh' and 'Roghani' from the first group had the most distant genetic relationship with 'Soltani' and 'Bangi' (Ghermez) from the ninth group. The native Iranian grape cultivars and genotypes of Khuzestan province 'Mocheh' and 'Roghani' had more relationship with other Iranian grape cultivars such as 'Asgari', 'Yaghouti Ghermez' and 'Yaghouti Sabz' as well as foreign cultivars of 'Flame Seedless' and 'Perlette'. In addition, other local and endemic Iranian grape cultivars and genotypes such as 'Soltani', 'Bangi' (Ghermez), 'Yershi', 'Sabz Dorosht' and 'Nameless' showed more genetic relationship with each other (Fig. 5 and Fig. 6).

Fig. 6. Variations observed in bunch characteristics (included size, color, shape) of grape cultivars and genotypes grown in vineyards of Khuzestan province. A) 'Yaghouti Ghermez', B) 'Mocheh', C) 'Roghani', D) 'Yershi' , E) 'Bangi' (Ghermez), F) 'Soltani', G) 'Nameless', H) 'Asgari', I) 'Flame Seedless', J) 'Perlette', K) 'Sabz Dorosht' and L) 'Yaghouti Sabz'.

DISCUSSION

Determination of genetic diversity in plant material is very important and is the first and fundamental step to identify, conserve and maintain genetic resources, which is the basic foundation for genetic research and breeding programs. In order to improve and produce new cultivars, it is necessary to have the power of accurate selection among plants, which depends on the identification of cultivars and the diversity in them. Studying the latent genetic diversity in the plant population, selecting the traits that are effective in production, and introducing superior cultivars will help. Also, the study of phenotypic and genotypic diversity is very important to identify similar genotypes in order to evaluate, use and conserve genetic resources.

The findings of this research showed that most of the traits among the cultivars and genotypes of the studied grapes, especially in the local grape cultivars of the tested region, were significantly different from each other due to their diverse morphological and phenological characteristics, which the research results of Salimov et al. (2017) and Razi et al. (2021) and Habib et al. (2020, 2021) were in agreement.

Jahnke et al. (2021) reported that genotypic differences cause variation in leafing time, flowering and fruiting time between different grape cultivars and genotypes. Based on the codes determined in the grape descriptor and in accordance with the results of Rasouli et al. (2013), Khadivi-Khub et al. (2014) and Salimov et al. (2017), in our research, flowering time with code 3-7 (early flowering - late flowering), leafing time with Code 3-5 (early leafing-late leafing) and fruit ripening time with code 3-7 (early ripening-late) were variable in grape cultivars and genotypes of Khuzestan province.

In this research, the shape of berries in the studied cultivars and genotypes was oval, wide oval and round, and the reason for the difference is mostly related to the type of variety and its distribution, which is according to the findings of Rasouli et al. (2013), Khadivi -Khub et al. (2014), Razi et al. (2021) have been more consistent regarding the variety of berry shape in similar growing conditions. According to him, different cultivars of grapes differ from each other in terms of length and width of berries, and seedless cultivars have small to medium bunch. In terms of the color of the skin and mesocarp in the berries, juiciness, berry weight and the presence of seeds, they differ from each other, which were similar to the opinion of Salimov et al. (2017) and Janke et al. (2021).

According to Dilli et al. (2014), vegetative and reproductive morphological traits such as leaf area, plant growth size, bunch weight and berry weight are highly correlated with changes in genetic traits. The results of the present research show a positive and significant correlation between the bunch and berry traits (r=0.71) with the findings of Rasouli et al. (2013). It matched. Cargnin (2018) in the study of ′Cabernet Sauvignon′ cultivars showed that fruit yield (weight) has a high and significant correlation with cluster weight (r=0.98) and berry weight (r=0.98). Also, in similar results, Cargenin (2018) in the study of ′Chardonnay′ cultivars showed that fruit yield (weight) had a positive and significant phenotypic correlation with bunch weight (r=0.91) and number of berries per bunch (r=0.88). According to Cargnin (2018), the higher the number of bunch per plant, the lower the weight of the bunch and berry weight, and as a result, the fruit yield is lower. But the selection based on traits with positive and significant correlation showed the potential of high fruit yield in the plant. These results confirm the findings obtained by different researchers who have studied the correlation between variables in grape production (Akram et al., 2021; Khalil et al., 2017; Vujović et al., 2017) and correlations that can be they observed significant correlations between grape variables (for example, between yield components, bunch weight and bunch size; berry weight and berry size and physicochemical characteristics).

The results of this research showed that bunch weight and berry weight have an inverse relationship with the number of bunch per plant and the number of berries per bunch. Increasing berries weight and bunch weight had a positive effect on increasing crop yield. The decrease in crop weight was due to the connection between the sink and the source due to the increase in the number of berries and the limitation in photosynthetic production. As the number of berries increased, the amount of assimilate produced was divided between them and led to a decrease in berry weight. Reducing the number of bunches per plant and the number of berries per bunch has increased the weight of the product. The decrease in vine yield weight was due to the increase in leaf weight and shoot weight. The distribution of photosynthetic substances in the plant during the growing season considering that the leaves are the main factor of photosynthesis. For the growth of leaves, the priority is to use photosynthetic materials with leaves, and when we reach the critical level of leaves, the priority is to use photosynthetic materials with shoot and roots, respectively. But in the stage of reproductive growth, with the growth of berries, the movement of materials to this part is prioritized and the growth of leaves and roots is stopped to a large extent. Knowing which sinks or sources limit the performance of a genotype can determine genotype improvement strategies using selection and breeding.

The results obtained from this research are consistent with the results of other researchers and show that increasing yield components such as number of berries per bunch, berry weight and number of berries per bunch leads to an increase in fruit yield. The results of the researchers show that the phenological and morphological traits with the range of low to high changes are significant, which indicates the heritability and genetic progress of the traits in different cultivars (Silva et al., 2009). Significant positive correlations between economic traits such as bunch length, bunch weight, number of berries per bunch, and berry width with fruit yield indicate that selection for these characteristics leads to an increase in grape yield (Dolkar et al., 2017; Gupta et al., 2015).

In this research, 7 principal components explained 28.84% of the total variance of the measured variables, which is in agreement with the results of Rasouli et al. (2013) in the study of 32 cultivars and genotypes of grapes with 10 factors in total 22.74% and the results of good Khadivi-khub et al. (2014) in the study of genetic diversity in 22 different grape cultivars explained 76.96% of the traits variance with 5 factors. In these studies, the most important traits included bunch weight, berry weight, bunch length and width, berry length and width, number of bunch per plant and number of kernels per berries, which were similar to the results obtained from our experiment.

Leão and Oliveira (2023) reported that the first and second principal components explained 59.2% of the variation. In PC1 (42.76%), the variable was related to the number of clusters, cluster weight, seed length and seed diameter, and in PC2 (16.4%) it was related to vine yield. which was consistent with our results.

The results of PCA analysis of this research were consistent with the findings of Ibacache et al. (2016) and Silva et al. (2017) reported that the variation in the number of clusters in Flame Seedless, Red Globe and Thompson cultivars on different bases is very high. Also, Leão et al. (2010) identified yield per vine, number of bunch per plant, bunch length, bunch weight, berry weight and size, titratable acidity and total soluble solids as prominent variables, which is consistent with the results of our experiment.

The results of cluster analysis by Ward’s method at 5 Euclidean distances in this research showed that the native Iranian grape cultivars and genotypes available in the vineyards of Khuzestan province, including 'Soltani', 'Bangi' (Ghermez), 'Yershi', 'Sabz Dorosht' and 'Nameless', are more closely related to each other due to their distribution in the vineyards of the province, and Iranian grape cultivars including 'Asgari', 'Yaghouti Ghermez' and 'Yaghouti Sabz' and the non-Iranian grape cultivars including 'Flame Seedless' and 'Perlette' had a much greater genetic distance from each other, which is consistent with the reports of Gholami et al. (2018) regarding the better efficiency of grouping based on the cultivars and genotypes studied, as well as the results of Basafa et al. (2008), Al-Saady et al. (2018) and Morales-Castilla et al. (2020), who found that genetic diversity and geographic diversity corresponded. Also, the native grape cultivars and genotypes of 'Mocheh' and 'Roghani' were genetically closely related to 'Perlette' and 'Asgari' cultivars and had a small genetic distance with 'Flame Seedless', 'Yaghouti Ghermez' and 'Yaghouti Sabz' cultivars. However, compared to other native and local Iranian grape cultivars and genotypes, they had a much larger genetic distance and showed higher genetic diversity. This high genetic difference between native and local grape cultivars and genotypes in vineyards of Khuzestan province shows that their primary habitats were probably far from each other and they were later transferred to secondary origin. In the grouping of grape cultivars and genotypes in vineyards of Khuzestan province, phenological characteristics such as leafing time, flowering time, earliness, growth strength and morphological characteristics such as all traits related to bunches and berries such as bunch shape, bunch and berry size, berry color and berry weight were the most obvious discriminating characteristics of grape cultivars and genotypes in different groups.

Furthermore, the results of cluster analysis in this research with the findings of Haj-Amiri (2011), Rasouli et al. (2013), Alizadeh (2013), Zainalu (2013), Nejadian (2015), Rasouli and Kalvandi, (2022), and Mirfatah et al. (2024) in the varieties available in Iran (from Kermanshah, Hamedan, West Azarbaijan, Qazvin and Isfahan provinces) in terms of different traits related to vegetative parts, bunch size, bunch weight, berry density per bunch, berry color, seeded or seedless, time of fruit ripening, as well as genetic affinity they had reported, were consistent.

The native grape cultivars and genotypes from Khuzestan province had higher plant growth, growth size of shoot, leaf area, bunch weight and berry weight compared to Iranian cultivars of 'Yaghouti Ghermez', 'Yaghouti Sabz' and 'Asgari' and foreign cultivars of 'Flame Seedless' and 'Perlette'.

The native grape cultivar of 'Bangi' (Ghermez) has a relatively high anthocyanin content in the mesocarp and skin of berry, as well as the Iranian cultivar of 'Yaghouti Ghermez' and foreign cultivars of 'Flame Seedless' and the native cultivar of 'Yershi' also has some anthocyanin in the mesocarp and skin of berry.

In terms of seed size and shape, the native cultivars and genotypes from Khuzestan province had bigger seeds and larger dimensions and relatively more seed hardness and seed skin thickness compared to other Iranian cultivars of 'Yaghouti Ghermez', 'Yaghouti Sabz' , 'Asgari' and the non-Iranian cultivars of 'Flame Seedless' and 'Perlette'.

The difference in vine growth vigour , berry size, berry density per bunch and berry weight, the presence of seeds per berry, seed size and leaf area, total soluble solids (TSS), and the content of resveratrol in different organs of the plant are among the most important different characteristics between and the native and local grape cultivars and genotypes from Khuzestan province such as 'Soltani', Bangi' (Ghermez), 'Yershi', 'Roghani', 'Mocheh', 'Sabz Dorosht' and 'Nameless' with other Iranian cultivars such as 'Yaghouti Ghermez', 'Yaghouti Sabz' and 'Asgari' and foreign cultivars such as 'Flame Seedless' and 'Perlette'were available in vineyards of Khuzestan province.

CONCLUSION

The purpose of this research, considering the specific climatic conditions of Khuzestan province of Iran, which has a tropical climate with a very short winter, without frost and with a temperature above zero degrees, knowledge of grape genetic reserves and identification of local cultivars and genotypes in the vineyards of Khuzestan province using phenological, morphological and pomological traits. In the climatic conditions of Khuzestan province, grape cultivars and genotypes, compared to other grape growing regions in Iran, come out of dormancy earlier and leaf buds are activated earlier. After that, the flowers appear faster. In this region, the grapes ripen and are harvested earlier and are not exposed to the late spring cold. Of course, this time coincides with the beginning of the peak of heat in the Khuzestan region, but the native cultivars do not face high environmental temperatures due to their early maturity. The native varieties and genotypes of grapes available in the region include 'Soltani', 'Bangi' (Ghermez), 'Yershi', 'Sabz Dorosht' and 'Nameless' in terms of final fruit yield, bunch weight, berry weight, berry number per bunch and bunch length, they assigned the highest amount. These cultivars and genotypes were superior compared to other investigated cultivars including 'Yaghouti Ghermez', 'Yaghouti Sabz' and 'Asgari' and even foreign cultivars 'Flame Seedless' and 'Perlette'. The native grape cultivars and genotypes 'Roghani' and 'Mocheh' were ranked lower than the others in this respect. Finally, it can be reported that the local cultivar or genotype of 'Soltani' grapes has the most diversity in the traits related to fruit yield, including bunch length, bunch width, bunch shoulder length, bunch shoulder width, number of berries in the bunch, fresh has had the weight of the bunch. Also, the 'Yaghouti Ghermez' cultivar had the highest dry weight of the bunch and the dry weight of the berries, and the local variety or genotype 'Yershi' had the longest bunch length.

Conflict of interest

All authors declare that they have no competing financial or personal relationships that could have influenced the work reported in this paper.

Acknowledgments

We are grateful to the heads of the Research Institute of Grape and Raisin (RIGR) of Malayer university, Malayer city, Iran, for their help in conducting the research.

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